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U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

6.2.1.4 MASS AND ENERGY RELEASE ANALYSIS FOR POSTULATED SECONDARY SYSTEM PIPE RUPTURES

REVIEW RESPONSIBILITIES

Primary - Containment Systems Branch (CSB)

Secondary - None

I. AREAS OF REVIEW

The CSB reviews the analyses of the mass and energy release to assure that the data used to evaluate the containment and subcompartment functional design are acceptable for that purpose. The CSB review includes the following areas:

1. The energy sources that are available for release to the containment.

2. The mass and energy release rate calculations.

The CSB also reviews the single-failure analyses performed for steam and feedwater line isolation provisions which would limit the flow of steam or feedwater to the assumed pipe rupture.

The Mechanical Engineering Branch (MEB) is responsible for reviewing the seismic classification and system quality group classification of steam and feedwater line isolation valves to determine the acceptability of these valves in limiting the mass and energy releases from the steam and feedwater system (see Standard Review Plan Sections 3.2.1 and 3.2.2).

The Auxiliary Systems Branch (ASB) reviews the time assumed for operator action to close manual valves in the auxiliary feedwater system. (See Standard Review Plan Section 10.4.9.)

II. ACCEPTANCE CRITERIA

The CSB acceptance criteria is based on meeting the requirements of General Design Criterion (GDC) 50, with respect to providing sufficient conservation in the mass and energy release analysis for postulated PWR secondary system pipe ruptures to assure that the containment design margin is maintained.

Specific criteria necessary to meet the relevant requirements of GDC 50 are as follows:

1. <u>Sources of Energy</u>

   The sources of energy that should be considered in analyses of steam and feedwater line break accidents include: the stored energy in the affected steam generator's metal, including the vessel tubing, feedwater line, and steam line; the stored energy in the water contained within the affected steam generator; the stored energy in the feedwater transferred to the affected steam generator prior to closure of the isolation valves in the feedwater line; the stored energy in the steam from the unaffected steam generator(s) prior to the closure of the isolation valves in the steam generator crossover lines; and the energy transferred from the primary coolant to the water in the affected steam generator during blowdown.

   The steam line break accident should be analyzed for a spectrum of pipe break sizes and various plant conditions from hot standby to 102% of full power. Only the 102% power condition need be analyzed provided the applicant can demonstrate that the feedwater flows and fluid inventory are greatest at full power.

2. <u>Mass and Energy Release Rate Calculations</u>

   In general, calculations of the mass and energy release rates during a steam or feedwater line break accident should be done in a manner that is conservative from a containment response standpoint; i.e., that maximizes the post-accident containment pressure and temperature. The following criteria indicate the degree of conservatism that is desired.

   Mass release rates should be calculated using the Moody model (Ref. 16) for saturated conditions, or a model that is demonstrated to be equally conservative.

   Calculations of heat transfer to the water in the affected steam generator should be based on nucleate boiling heat transfer.

   Calculations of mass release should consider the water in the affected steam generator and feedwater line, the feedwater transferred to the affected steam generator prior to the closure of the isolation valves in the feedwater lines, the steam in the affected steam generator, and the steam coming from the unaffected steam generator(s) as the secondary system is being depressurized prior to the closure of the isolation valves in the steam generator crossover lines.

   If liquid entrainment is assumed in the steam line breaks, experimental data should support the predictions of the liquid entrainment model. The effect on the entrained liquid of steam separators located upstream from the break should be taken into account. A spectrum of steam line breaks should be analyzed, beginning with the double-ended break and decreasing in area until no entrainment is calculated to occur, to allow selection of the maximum release case.

If no liquid entrainment is assumed, a spectrum of the steam line breaks should be analyzed beginning with the double-ended break and decreasing in area until it has been demonstrated that the maximum release rate has been considered.

A single active failure in the steam or feedwater line isolation provisions or feedwater pumps, such that the containment peak pressure and temperature are maximized, should be assumed to occur in steam and feedwater line break analyses. For the assumed failure of a safety grade steam or feedwater line isolation valve, operation of nonsafety grade equipment may be relied upon as a backup to the safety grade equipment. In this event, the CSB reviewer will confer with the ASB and MEB reviewers to ensure a consistent staff position regarding the acceptability of the design criteria for the nonsafety grade equipment.

Feedwater flow to the affected steam generator should be calculated considering the diversion of flow from the other steam generators, feedwater flashing and increased feedwater pump flow caused by the reduction in steam generator pressure. An acceptable method for computing feedwater flow is to assume all feedwater travels to the affected steam generator at the pump runout rate before isolation. After isolation, the unisolated feedwater mass should be added to the affected steam generator. The RELAP4 code may also be used to compute feedwater flow.

Operator action to terminate auxiliary feedwater flow will be reviewed by ASB. (See SRP Section 10.4.9.)

Acceptable computer codes for calculating mass and energy releases for steam line breaks are SGN-III (Ref. 19) and TRAP-2 (Ref. 31). Other methods will be acceptable if they are found by CSB to be conservative for these calculations.

III. REVIEW PROCEDURES

The procedures described below are followed for the review of the mass and energy release analysis of secondary coolant systems pipe breaks. The reviewer selects and emphasizes material from these procedures as may be appropriate for a particular case. Portions of the review may be carried out on a generic basis or by applying the results of previous reviews of similar plants.

The CSB reviews the secondary coolant system pipe breaks analysis assumptions to determine whether the "worst" pipe break accident case has been identified by the applicant, and whether the analysis was done in a conservative manner from the standpoint of containment pressure and temperature.

This review involves the proposed methods and models used for blowdown analyses. The acceptability of the approach used by the applicant is evaluated based on the acceptance criteria in subsection II of this SRP section. The CSB also reviews analyses of postulated single failures of active components in the secondary systems, such as steam and feedwater line isolation valves and feedwater pumps, to determine whether the single failure has been selected which maximizes containment pressure and temperature.

The CSB will request MEB to review the acceptability of nonsafety valves in limiting the mass and energy releases from the steam and feedwater systems. The CSB will request the ASB to review the rationale for determining the time at which operator action can be relied upon to terminate auxiliary feedwater flow to the affected steam generator. The CSB will review the applicant's calculations for main feedwater flow into the affected steam generator to determine that the flow rate is conservatively maximized.

If liquid entrainment is calculated in the applicant's steam line break model, the CSB will determine the validity of the experimental data provided to support the entrainment calculation. The CSB will also ascertain that the effect of steam separators located upstream from the postulated steam line break have been taken into account in the analysis. The CSB reviews comparisons to experimental data made by the applicant and makes comparisons to other available experimental data to determine the amount of conservatism in the mass and energy release models.

The CSB reviews the results of a spectrum of steam line breaks, beginning with the double-ended break and decreasing in area until no entrainment occurs, to be sure that the steam line break size producing the highest containment temperature and pressure has been identified.

The CSB performs confirmatory analyses of the containment pressure and temperature response to steam and feedwater line breaks inside the containment using the CONTEMPT-LT computer code.

IV. EVALUATION FINDINGS

The conclusions reached on completion of the review of this SRP section are presented in Standard Review Plan Section 6.2.1.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

VI. REFERENCES

The references for this SRP section are listed in Standard Review Plan Section 6.2.1.